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(54) **ELONGATED LED LUMINAIRE AND ASSOCIATED METHODS**

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F21V 29/70 (2015.01)
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(52) **U.S. Cl.**
CPC . ***F21K 9/175*** (2013.01); ***F21K 9/50*** (2013.01); ***F21K 9/52*** (2013.01); ***F21V 17/06*** (2013.01);
(Continued)

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USPC 362/558, 249.02, 244–247, 218, 362/217.02–217.07
See application file for complete search history.

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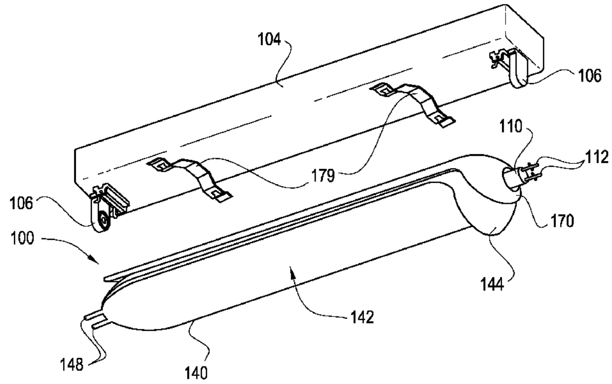
(74) *Attorney, Agent, or Firm* — Mark Malek; Stephen Bullock; Widerman Malek, PL

(57) **ABSTRACT**

A luminaire comprising a lamp comprising an outer structure, a light source configured to emit a source light and carried by the outer structure, a middle structure connected to the outer structure, and a bi-pin base connected to the middle structure. The lamp may further comprise a light guide having an inner surface and an outer surface and a heat dissipating frame having a contact surface in thermal communication with the outer surface of the light guide and comprising a plurality of heat sink rods positioned to abut each other to define the contact surface of the heat dissipating frame. The light source may be configured to emit the source light so as to be incident upon the inner surface of the light guide. The light guide may be configured to change the source light into a shaped light that illuminates a space proximate to the luminaire.

20 Claims, 6 Drawing Sheets



(51) **Int. Cl.**
F21V 17/06 (2006.01)
F21Y 101/02 (2006.01)

(52) **U.S. Cl.**
CPC . ***F21V 29/70*** (2015.01); *F21K 9/90* (2013.01); *F21Y 2101/02* (2013.01); *Y02B 20/386* (2013.01); *Y10T 29/49117* (2015.01)

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Response to Non-Final Office Action dated Apr. 22, 2015 filed in related U.S. Appl. No. 14/044,939 (8 pages).

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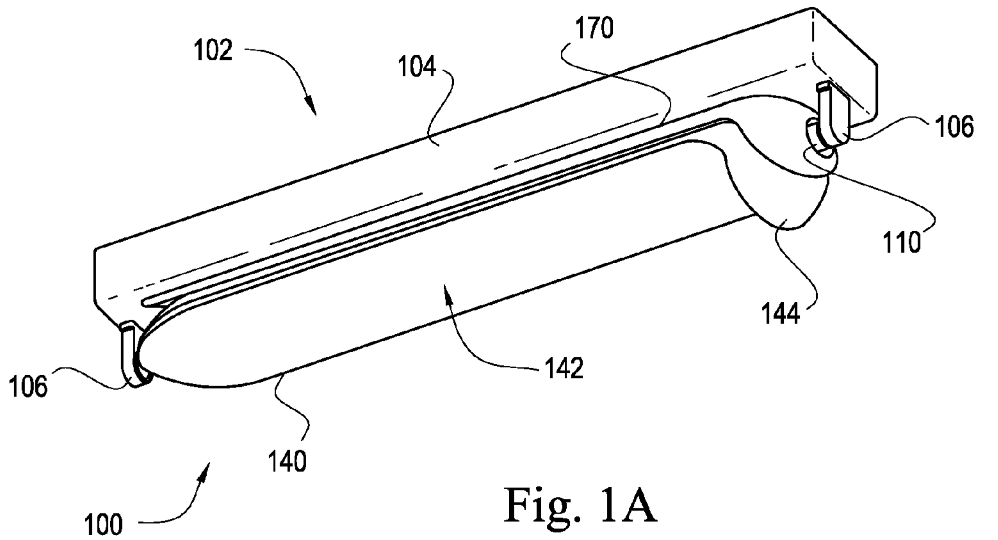
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Fig. 1A

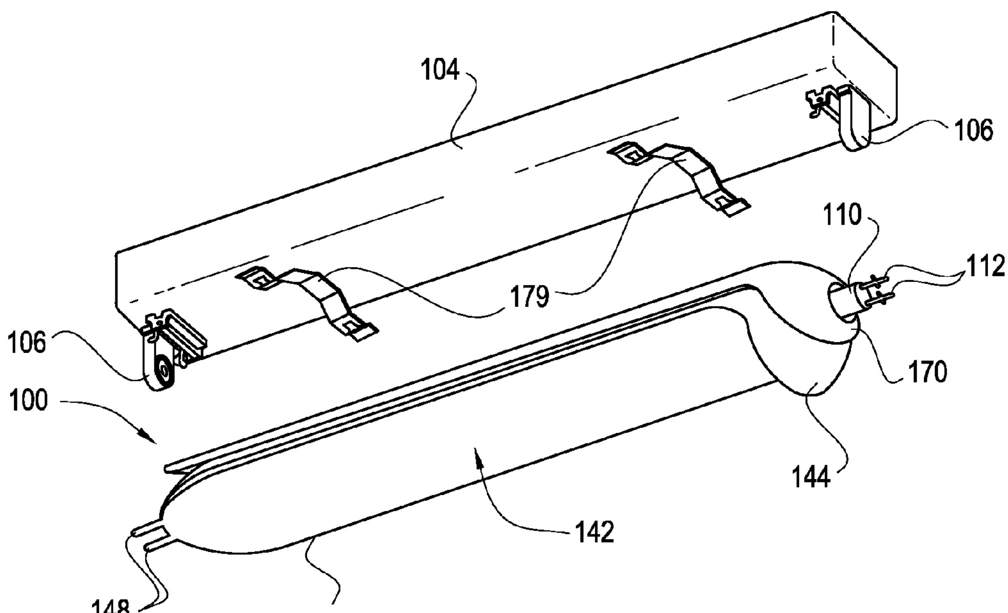
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Fig. 1B

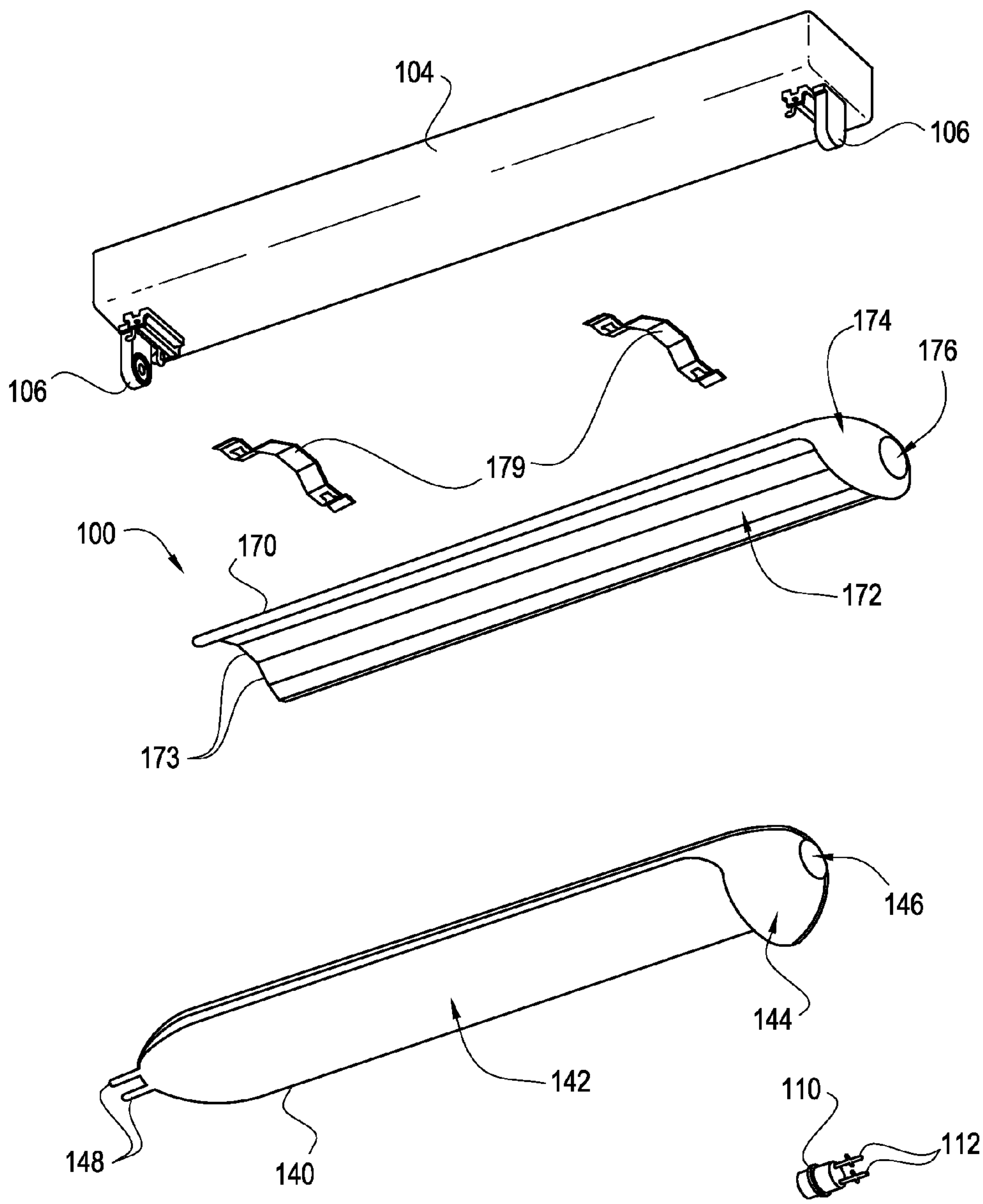
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Fig. 1C

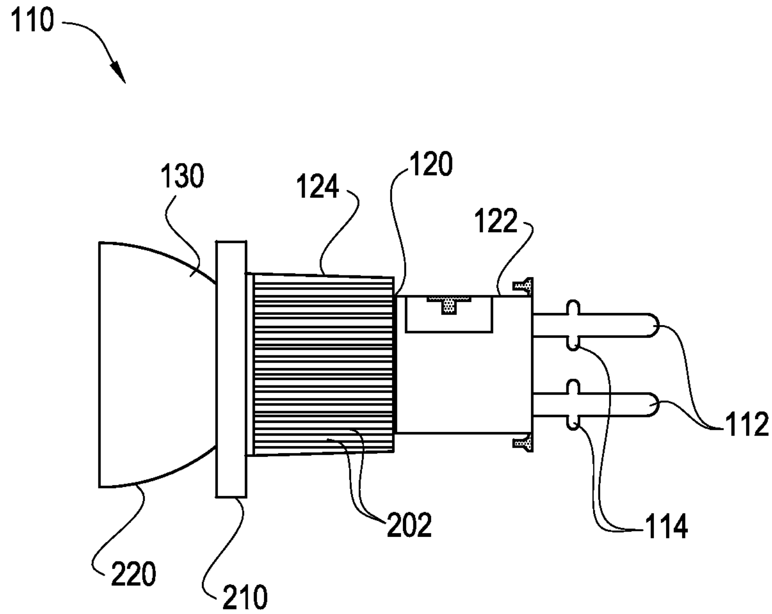


Fig. 2A

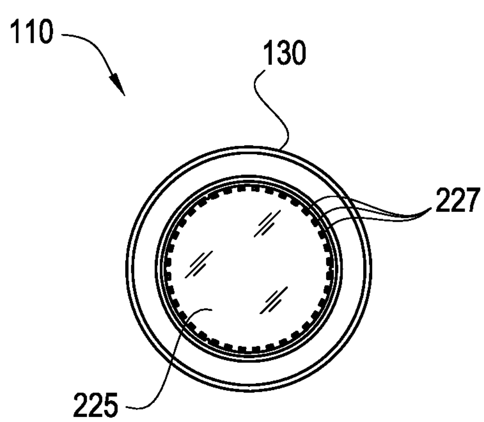


Fig. 2B

Fig. 3A

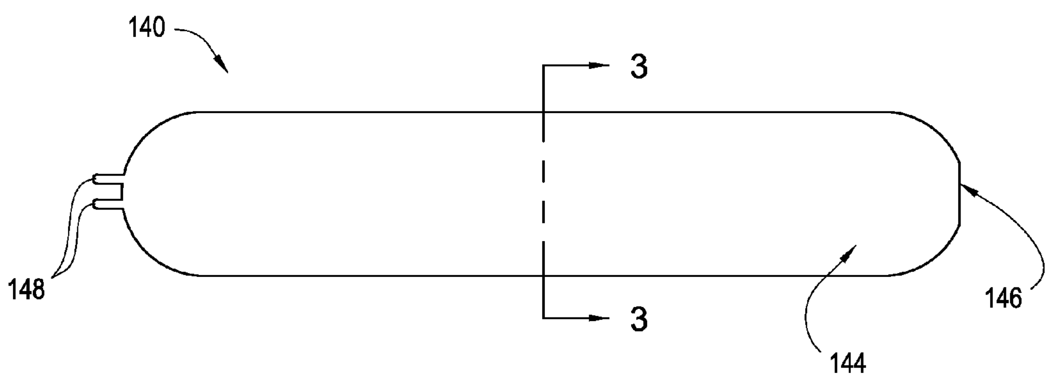


Fig. 3B

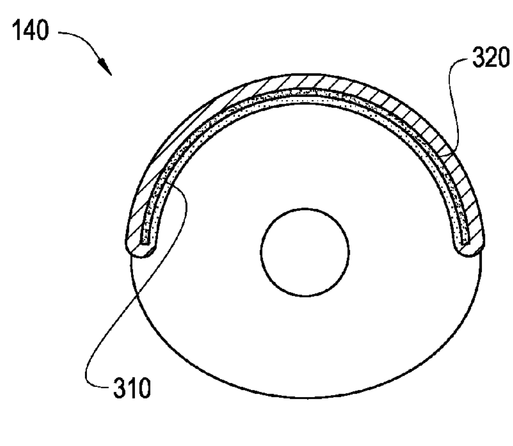


Fig. 3C

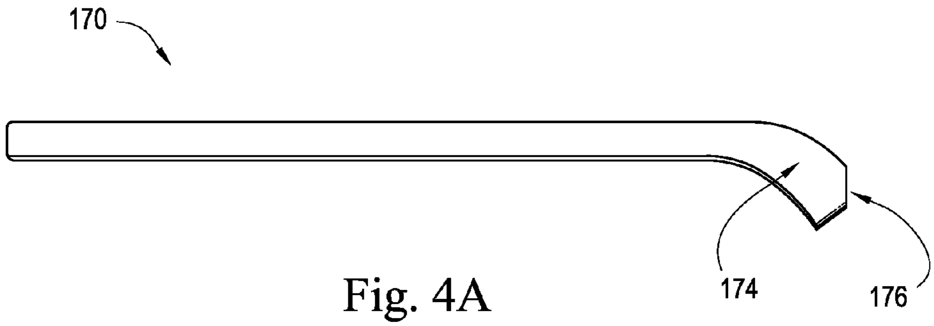


Fig. 4A

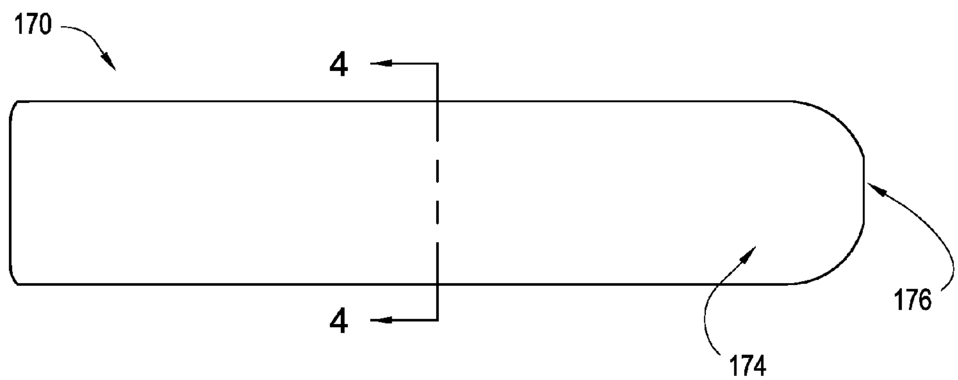


Fig. 4B

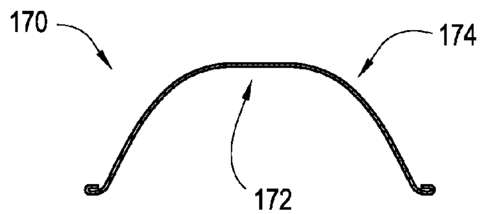
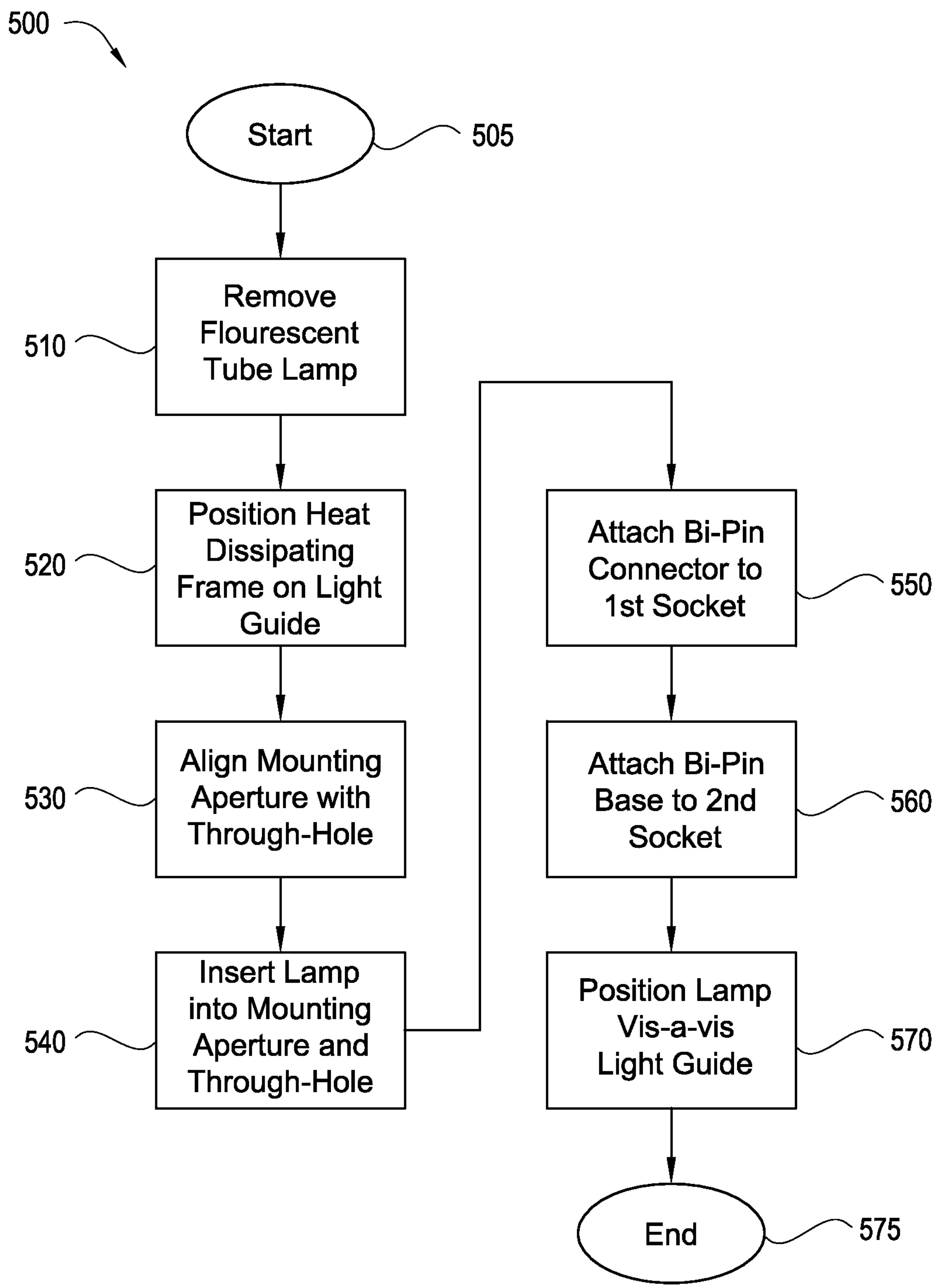


Fig. 4C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505
Remove Flourescent Tube Lamp
510
Position Heat Dissipating Frame on Light Guide
520
Align Mounting Aperture with Through-Hole
530
Insert Lamp into Mounting Aperture and Through-Hole
540
Attach Bi-Pin Connector to 1st Socket
550
Attach Bi-Pin Base to 2nd Socket
560
Position Lamp Vis-a-vis Light Guide
570
End
575

Fig. 5

ELONGATED LED LUMINAIRE AND ASSOCIATED METHODS

RELATED APPLICATIONS

This application is a continuation of and claims the benefit under 35 U.S.C. §120 of U.S. patent application Ser. No. 14/044,939 filed on Oct. 3, 2013 and titled Elongated LED Luminaire and Associated Methods, which in turn claims the benefit under 119(e) of U.S. Provisional Patent Application Ser. No. 61/709,325 filed on Oct. 3, 2012 and titled Elongated LED Lighting System and Associated Methods, the entire contents of each of which are incorporated herein by reference, except to the extent disclosures therein are inconsistent with disclosure herein.

FIELD OF THE INVENTION

The present invention relates generally to the field of lighting and, in particular, to luminaires used to replace fluorescent lamps, and associated methods.

BACKGROUND OF THE INVENTION

A fluorescent lamp (also called a fluorescent tube) uses electrical current to excite a vapor within a glass tube resulting in the discharge of electrons. Visible light is produced when the electrons cause a material coating the inner wall of the glass tube to fluoresce. Linear fluorescent lamps are routinely used in commercial or institutional buildings, and are commonly installed in troffer light fixtures (recessed troughs installed in a ceiling) and pendant light fixtures (housings suspended from a ceiling by a chain or pipe).

Fluorescent lamps have been steadily replacing incandescent lamps in many lighting applications. Compared to an incandescent lamp, a fluorescent lamp converts electrical power into useful light more efficiently, delivers a significantly longer useful life, and presents a more diffuse and physically larger light source. However, fluorescent lamp technology has disadvantages. A fluorescent lamp is typically more expensive to install and operate than an incandescent lamp because the fluorescent lamp requires a ballast to regulate the electrical current. Fluorescent light fixtures cannot be connected directly to dimmer switches intended for incandescent lamps, but instead require a compatible dimming ballast. The performance of fluorescent lamps may be negatively impacted by environmental conditions such as frequent switching and operating temperatures. Many fluorescent lamps have poor color temperature, resulting in a less aesthetically pleasing light. Some fluorescent lamps are characterized by prolonged warm-up times, requiring up to three minutes before maximum light output is achieved. Also, if a fluorescent lamp that uses mercury vapor is broken, a small amount of mercury (classified as hazardous waste) can contaminate the surrounding environment.

Digital lighting technologies such as light-emitting diodes (LEDs) offer significant advantages over traditional linear fluorescent lamps. These include, but are not limited to, better lighting quality, longer operating life, and lower energy consumption. Increasingly, LEDs are being designed to have desirable color temperatures. Moreover, LEDs do not contain mercury. Consequently, a market exists for LED-based retrofit alternatives to legacy lighting fixtures that use fluorescent lamps. However, a number of installation challenges and costs are associated with replacing linear fluorescent lamps with LED illumination devices. The challenges, which are understood by those skilled in the art, include light production, thermal management, and installation ease. The costs, which are similarly understood by those skilled in the art, typically stem from a need to replace or reconfigure a troffer or pendant fixture that is configured to support fluorescent lamps to instead support LEDs.

By the very nature of their design and operation, LEDs have a directional light output. Consequently, employing LEDs to produce light distribution properties approximating or equaling the light dispersion properties of traditional lamps may require the costly and labor-intensive replacement or reconfiguration of the host light fixture, and/or the expensive and complexity-introducing design of LED-based solutions that minimize the installation impact to the host light fixture. Often material and manufacturing costs are lost in this trade off.

Another challenge inherent to operating LEDs is heat. Thermal management describes a system's ability to draw heat away from the LED, either passively or actively. LEDs suffer damage and decreased performance when operating in high-heat environments. Moreover, when operating in a confined environment, the heat generated by an LED and its attending circuitry itself can cause damage to the LED. Heat sinks are well known in the art and have been effectively used to provide cooling capacity, thus maintaining an LED-based light bulb within a desirable operating temperature. However, heat sinks can sometimes negatively impact the light distribution properties of the light fixture, resulting in non-uniform distribution of light about the fixture. Heat sink designs also may add to the weight and/or profile of an illumination device, thereby complicating installation, and also may limit available space for other components needed for delivering light.

Replacement of legacy lighting solutions may be complicated by the need to adapt LED-based devices to meet legacy form standards. For example, in a commercial lighting system retrofit, disposal of a replaced fluorescent lamp's fixture housing often is impractical. Consequently, retrofit lamps often are designed to adapt to a legacy fluorescent fixture, both functionally and aesthetically. Also, power supply requirements of LED-based lighting systems can complicate installation of LEDs as a retrofit to existing light fixtures. LEDs are low-voltage light sources that require constant DC voltage or current to operate optimally, and therefore must be carefully regulated. Too little current and voltage may result in little or no light. Too much current and voltage can damage the light-emitting junction of the LED. LEDs are commonly supplemented with individual power adapters to convert AC power to the proper DC voltage, and to regulate the current flowing through during operation to protect the LEDs from line-voltage fluctuations. The lighting industry is experiencing advancements in LED applications, some of which may be pertinent to certain aspects of replacing linear fluorescent lamps.

U.S. Pat. No. 6,739,734 to Hulgan discloses a method of retrofitting a fluorescent light fixture (e.g., four foot T12or T8 lamps) with LED-based luminaires without requiring removal of the fixture housing. However, rather than maintain existing circuitry, the fixture is stripped not only of its fluorescent lamps but also of its wireway cover and ballast(s). U.S. Published Patent Application No. 2010/0033095 by Sadwick discloses an apparatus for replacing a fluorescent lamp that includes an electrical connector adapted to maintain the existing circuitry of the fixture, including the fluorescent ballast. A voltage converter, direct current (DC) rectifier, and LED light source included in the apparatus simulate the behavior of a fluorescent lamp in response to signals from the fixture's existing circuitry. However, the reference defines a lamp housing physically configured as a prosthetic replacement for a fluorescent lamp in the fixture, rather than as a less expensive non-tubular light-directing structure.

U.S. Pat. No. 6,936,968 to Cross et al., U.S. Pat. No. 6,997,576 to Lodhie, and U.S. Published Patent Application No. 2012/0147597 by Farmer and all disclose versions of an LED light tube adapted for use in troffer light fixtures. The Cross reference defines a cylindrical elongated transparent envelope holding at least one serial string of LEDs along its length. Similarly, the Lodhie reference discloses a substantially transparent hollow cylinder containing multiple LEDs arranged to form two LED arrays, and mounted along opposite sides of a substantially planar printed circuit board (PCB). The Farmer reference also defines a tubular structure, but employs one or more side light LEDs combined with gradient optics to achieve a selected emitted light intensity variation across the surface of the tube. Once again, all three references define a lamp housing physically configured as a prosthetic replacement for a fluorescent lamp in the fixture, rather than as a less expensive non-tubular light-directing structure.

Accordingly, and with the above in mind, a need exists for an effective and inexpensive fluorescent lamp replacement. More specifically, a need exists for a fluorescent lamp replacement that may be employed with minimal reconfiguration of the existing troffer or pendant light fixture that supported the replaced lamp. A fluorescent lamp replacement is needed that may be manufactured at less cost than conventional retrofit lamps. Furthermore, a need exists for a fluorescent lamp that meets or exceeds the performance characteristics of fluorescent lamps, but also delivers the advantages of digital lighting technology (e.g., energy efficiency, tailorable color temperatures).

This background information is provided to reveal information believed by the applicant to be of possible relevance to the present invention. No admission is necessarily intended, nor should be construed, that any of the preceding information constitutes prior art against the present invention.

SUMMARY OF THE INVENTION

With the above in mind, embodiments of the present invention are related to a luminaire adapted to be carried by a lighting fixture. The luminaire may comprise a lamp, the lamp comprising an outer structure, a light source that may be configured to emit a source light and carried by the outer structure, a middle structure connected to the outer structure, and a bi-pin base connected to the middle structure. The luminaire may comprise a light guide having an inner surface and an outer surface and a heat dissipating frame having a contact surface in thermal communication with the outer surface of the light guide and comprising a plurality of heat sink rods positioned to abut each other to define the contact surface of the heat dissipating frame. The light source may be configured to emit the source light so as to be incident upon the inner surface of the light guide. Furthermore, the light guide may be configured to change the source light into a shaped light that illuminates a space proximate to the luminaire.

In some embodiments, the bi-pin base comprises a pin lock configured to anchor the lamp to a standard fluorescent socket. Additionally, the outer structure of the lamp may further comprise a shelf and an optic. Furthermore, the light source may be disposed on the shelf and oriented such that the source light emitted from the light source passes through the optic.

In some embodiments, the light guide may further be configured to change the source light into the shaped light using at least one of collimation, concentration, refraction, conversion, reflection, and diffusion. Additionally, the inner surface of the light guide may comprise an optically transmissive material and a reflective material that are configured, in combination, to change the source light into the shaped light.

In some embodiments, the light guide may comprise a conversion material configured to convert a wavelength of the source light so that the wavelength of the shaped light is defined as having a converted wavelength range. Additionally, the light guide may comprise a bi-pin connector configured to mechanically attach to a standard fluorescent socket. Furthermore, the light guide may comprise a mounting aperture positioned opposite the bi-pin connector. The mounting aperture may be sized to fittedly receive at least one of the bi-pin base and the middle structure of the lamp such that a portion of the outer structure of the lamp is positioned adjacent to the light guide. Furthermore, the light guide comprises a substantially elongated-basket shape between the bi-pin connector and the mounting aperture.

In some embodiments, the heat dissipating frame comprises a through-hole positioned on a substantially frusto-conical attaching end of the heat dissipating frame.

Additionally, embodiments of the present invention are related to a luminaire comprising a lamp comprising an outer structure, a light source configured to emit a source light and carried by the outer structure, a middle structure connected to the outer structure, and a bi-pin base connected to the middle structure. The luminaire may further comprise a light guide having an inner surface and an outer surface and comprising a bi-pin connector configured to mechanically attach to a standard fluorescent socket, and a mounting aperture positioned opposite the bi-pin connector. The mounting aperture may be sized to fittedly receive at least one of the bi-pin base and the middle structure of the lamp such that a portion of the outer structure of the lamp is positioned adjacent to the light guide. Furthermore, the luminaire may comprise a heat dissipating frame having a contact surface in thermal communication with the outer surface of the light guide. The light source may be configured to emit the source light so as to be incident upon the inner surface of the light guide. Additionally, the light guide may be configured to change the source light into a shaped light that illuminates a space proximate to the luminaire.

In some embodiments, the bi-pin base may comprise a pin lock configured to anchor the lamp to a standard fluorescent socket. Furthermore, the outer structure of the lamp further may comprise a shelf and an optic, and the light source may be disposed on the shelf and oriented such that the source light emitted from the light source passes through the optic. Additionally, the light guide may be further configured to change the source light into the shaped light using at least one of collimation, concentration, refraction, conversion, reflection, and diffusion.

In some embodiments, the inner surface of the light guide may comprise an optically transmissive material and a reflective material that are configured, in combination, to change the source light into the shaped light. Furthermore, the light guide may comprise a conversion material configured to convert a wavelength of the source light so that the wavelength of the shaped light is defined as having a converted wavelength range. Additionally, the light guide may comprise a bi-pin connector configured to mechanically attach to a standard fluorescent socket.

In some embodiments, the heat dissipating frame may comprise a through-hole positioned on a substantially frustoconical attaching end of the heat dissipating frame. Furthermore, the light guide may comprise a substantially elongated-basket shape between the bi-pin connector and the mounting aperture. Additionally, the middle structure may comprise a heat sink section in thermal communication with the light source. The heat dissipating frame may comprise a through-hole disposed on an attaching end of the heat dissipating frame and positioned such that a rim of the through-hole is in thermal communication with the heat sink section of the middle structure of the luminaire.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is an assembled, perspective bottom view of an elongate LED luminaire used in connection with a troffer fixture according to an embodiment of the present invention.

FIG. **1**B is a first exploded perspective view of the elongate LED luminaire illustrated in FIG. **1**A.

FIG. **1**C is a second exploded perspective view of the elongate LED luminaire illustrated in FIG. **1**A.

FIG. **2**A is a side elevation view of a lamp of the elongate LED luminaire illustrated in FIG. **1**A.

FIG. **2**B is a front elevation view of the lamp illustrated in FIG. **2**A.

FIG. **3**A is a side perspective view of a light guide of the elongate LED luminaire illustrated in FIG. **1**A.

FIG. **3**B is a top plan view of the light guide illustrated in FIG. **3**A.

FIG. **3**C is a cross-sectional view of the light guide illustrated in FIG. **3**A and taken through line **3-3** in FIG. **3**B.

FIG. **4**A is a side elevation view of a heat dissipating frame of the elongate LED luminaire illustrated in FIG. **1**A.

FIG. **4**B is a top plan view of the heat dissipating frame illustrated in FIG. **4**A.

FIG. **4**C is a cross-sectional view of the heat dissipating frame illustrated in FIG. **4**A and taken through line **4-4** in FIG. **4**B.

FIG. **5** is a flow chart detailing a method of retrofitting a fluorescent tube lamp with an elongate LED luminaire according to an embodiment of the present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention will now be described more fully hereinafter with reference to the accompanying drawings, in which preferred embodiments of the invention are shown. This invention may, however, be embodied in many different forms and should not be construed as limited to the embodiments set forth herein. Rather, these embodiments are provided so that this disclosure will be thorough and complete, and will fully convey the scope of the invention to those skilled in the art. Those of ordinary skill in the art realize that the following descriptions of the embodiments of the present invention are illustrative and are not intended to be limiting in any way. Other embodiments of the present invention will readily suggest themselves to such skilled persons having the benefit of this disclosure.

Although the following detailed description contains many specifics for the purposes of illustration, anyone of ordinary skill in the art will appreciate that many variations and alterations to the following details are within the scope of the invention. Accordingly, the following embodiments of the invention are set forth without any loss of generality to, and without imposing limitations upon, the claimed invention.

In this detailed description of the present invention, a person skilled in the art should note that directional terms, such as "above," "below," "upper," "lower," and other like terms are used for the convenience of the reader in reference to the drawings. Also, a person skilled in the art should notice this description may contain other terminology to convey position, orientation, and direction without departing from the principles of the present invention. Like numbers refer to like elements throughout.

The terms "generally" and "substantially" may be used throughout the application. "Generally" may be understood to mean approximately, about, or otherwise similar in content or value. "Substantially" may be understood to mean mostly, more than not, or approximately greater than half. The meanings of these terms must be interpreted in light of the context in which they are used, with additional meanings being potentially discernible therefrom.

Referring now to FIGS. **1**A-**5**, a luminaire **100** according to an embodiment of the present invention is now described in detail. Throughout this disclosure, the present invention may be referred to as the luminaire **100**, a lighting system, a digital light, an LED lighting system, a device, a system, a product, and a method. Furthermore, in the following disclosure, the present invention may be referred to as relating to replacement of linear fluorescent lamps, fluorescent tube lamps, tube lights, troffer tubes, and fluorescent light bulbs. Those skilled in the art will appreciate that this terminology is only illustrative and does not affect the scope of the invention. For instance, the present invention may just as easily relate to lasers or other digital lighting technologies, and may operate as a retrofit for non-linear troffer tubes or to other fluorescent light configurations.

Example devices, systems, and methods for an elongate LED luminaire are described herein below. In the following description, for purposes of explanation, numerous specific details are set forth to provide a thorough understanding of example embodiments. It will be evident, however, to one of ordinary skill in the art that the present invention may be practiced without these specific details and/or with different combinations of the details than are given here. Thus, specific embodiments are given for the purpose of simplified explanation and not limitation.

Referring now to FIGS. **1**A, **1**B, and **1**C, an elongate LED luminaire **100** configured to be carried by a light fixture will now be discussed. In various implementations, the luminaire **100** shown as part of a lighting assembly **102** in FIG. **1**A and also shown separately as a luminaire **100** in FIGS. **1**B and **1**C may be used alone or together with other similar lighting assemblies in a system of lighting assemblies. For example, and without limitation, the luminaire **100** may be configured as a retrofit to engage mechanically and operationally with a conventional fluorescent light fixture such as the light fixture **104** illustrated in FIGS. **1**A-**1**C. Used alone or in combination with other lighting assemblies, the luminaire **100** may be advantageously employed as a fluorescent tube replacement in a variety of applications including, but not limited to, direct-view or indirect-view interior or exterior space (e.g., architectural) lighting and illumination in general. The luminaire **100** may also be advantageously used in connection with direct or indirect illumination of objects or spaces, theatrical or other entertainment-based/special effects lighting, decorative lighting, safety-oriented lighting, lighting associated with, or illumination of, displays and/or merchandise (e.g. for advertising and/or in retail/consumer environments), combined lighting or illumination and communication systems, as well as for various indication, display and information purposes.

More specifically, the luminaire **100**, according to an embodiment of the present invention, may include a lamp

110, a light guide 140 positioned in optical communication with the lamp 110, and a heat dissipating frame 170 positioned in thermal communication with at least one of the lamp 110 and the light guide 140. Additionally, the luminaire 100 may further include one or more mounting brackets 179 adapted to mechanically attach the luminaire 100 to a light fixture 104. Although luminaire 100 is depicted as having an elongated basket shape in FIGS. 1A-1C, luminaire 100 and its constituent components may have any of a variety of other shapes, including planar and cylindrical.

Referring additionally to FIGS. 2A and 2B, the lamp 110, according to an embodiment of the present invention, may include a bi-pin base 112, a middle structure 120 connected to the bi-pin base 112, and an outer structure 130 connected to the middle structure 120. The outer structure 130 may be attached to the middle structure 120 which, in turn, may be similarly connected to the bi-pin base 112 by any means known in the art, including, not by limitation, use of one or more of adhesives or glues, welding, and fasteners. In defining the middle structure 120 and outer structure 130, reference is made herein specifically to FIGS. 2, 8, 9A, 9B, and 11, and the written description thereof, of U.S. patent application Ser. No. 12/698,829 titled Luminaire With Prismatic Optic filed on May 3, 2012, the entire content of which is incorporated herein by reference.

Continuing to refer to FIGS. 1A, 1B, 1C, and 2A, the bi-pin base 112 may be configured to anchor to a fluorescent socket 106. More specifically, the bi-pin base 112 may be configured to mechanically and electrically couple the lamp 110 to any standard fluorescent socket of a type that is well known in the art, including, but not limited to, medium bi-pin sockets (T8/T12), mini bi-pin sockets (T5/T5HO), single pin sockets (T12/T8), and U-bend medium bi-pin sockets. Additionally, the lamp 110 may be configured to conform to various sizes and configurations of the aforementioned sockets, including, but not limited to, turn-type sockets, pedestal sockets, and fixed-end sockets. For example, and without limitation, the bi-pin base 112 may include pin locks 114 designed to engage the fluorescent socket 106 from within the fluorescent socket pin contacts, rather than relying on pressure applied from outside the socket pin contacts to keep the lamp 110 from disengaging from the socket pin contacts due to minimal forces, such as gravity. Also for example, and without limitation, the bi-pin base 112 may be formed of an electrically conductive material, such as copper and/or aluminum.

Referring again to FIGS. 2A and 2B, the middle structure 120 of the lamp 110 may be configured to include a housing section 122 and a heat sink section 124. In the present embodiment, the heat sink section 124 may be formed of thermally conductive material and may be positioned in thermal communication with a light source 255. Materials of the heat sink section 124 may include, without limitation, thermoplastic, ceramics, porcelain, aluminum, aluminum alloys, metals, metal alloys, carbon allotropes, and composite materials. A portion of the heat sink section 124 may include a plurality of fins 202. For example, and without limitation, the fins 202 may be configured to run the length of the heat sink section 124 and may extend radially outward therefrom such that at least a distal edge of the fins 202 are substantially exposed to an environment external to the luminaire. The fins 202 may increase the surface area of the heat sink section 124 and may permit fluid flow between adjacent pairs of fins 202, thereby enhancing the cooling capability of the heat sink section 124. Additional information directed to the use of heat sinks for dissipating heat in an illumination apparatus is found in U.S. Pat. No. 7,922,356 titled Illumination Apparatus for Conducting and Dissipating Heat from a Light Source, and in U.S. Pat. No. 7,824,075 titled Method and Apparatus for Cooling a Light Bulb, the entire contents of each of which are incorporated herein by reference.

Continuing to refer to FIG. 2A, a proximal side of the substantially-cylindrical heat sink section 124 may be positioned adjacent to a distal side of the substantially-cylindrical housing section 122 of the middle structure 120. For example, and without limitation, each of the heat sink section 124 and the housing section 122 of the middle structure 120 shown in FIG. 2A may include a void such that the two voids cooperate with each other to define a longitudinal cavity (see also 208 in FIG. 2 of U.S. patent application Ser. No. 12/698,829 which is incorporated herein by reference). Electrical circuitry may be configured to be substantially enclosed within the middle structure 120 according to an embodiment of the invention. For example, and without limitation, a power source (not shown) may be configured to have a shape and sufficient dimensions to be disposed within the longitudinal cavity 208 of the middle structure 120.

The power supply may be configured to convert and condition AC power to DC power for delivery to the light source 225. In one embodiment, the bi-pin base 112 may conduct power from a light fixture that may provide 120-volt alternating current (AC) power. Furthermore, in the embodiment, the light source 225 may comprise LEDs 227 requiring direct current (DC) power at, for instance, five (5) volts. Accordingly, the power supply may comprise circuitry for conditioning the 120-volt AC power to 5-volt DC power. The characteristics of the power being provided to the power supply and be provided by the power supply are exemplary only, and a wide range of characteristics of electricity are contemplated included within the scope of the invention. For example, the bi-pin base 112 may conduct power from a light fixture that may provide power having a voltage within the range of from about 110 votes to about 250 V and a frequency within the range from about 40 Hz to about 70 Hz. Details regarding power supply systems that may be used in connection with the luminaire 100 according to an embodiment of the present invention may be found, for example, in U.S. Provisional Patent Application No. 61/486,322 titled Variable Load Power Supply, the entire content of which is incorporated herein by reference.

Continuing to refer to FIGS. 2A and 2B, according to an embodiment of the present invention, the outer structure 130 may include a shelf 210, an optic 220, and one or more light sources (225). The outer structure 130 may be configured to permit the one or more light sources 225 to be disposed therein and positioned to direct light through the optic 220. In the present embodiment, the shelf 210 may be disposed about a perimeter of the outer structure 130 adjacent the interface between the outer structure 130 and the middle structure 120.

Each light source 225 carried by the outer structure 130 may be provided as one of any number of embodiments. For example, and without limitation, any one of the light sources 225 may include light emitting elements 227. The light emitting elements 227 that may be included in the outer structure 130 may include one or more light-emitting diodes (LEDs) 227. It should be appreciated by the skilled artisan that the lock lamp 110 illustrated in FIG. 2B may include any number of various types of light sources (e.g., all LED-based light sources, LED-based and non-LED-based light sources in combination, etc.) adapted to generate radiation of a variety of different colors, including essentially white light, as will be discussed further below. More specifically, embodiments of the present invention contemplate that any number of light sources may be provided, in addition to any number of different light sources.

Each light source **225** may be configured to emit a source light, which may be defined as a combination of the emissions of each light source **225** present in the lamp **110**. Each light source **225** may be configured such that the emitted source light may be incident upon an inner surface **142** of the light guide **140** and subsequently projected generally radially outward from the lamp **110**. For example, and without limitation, the light guide **140** may be configured to alter the source light to create a shaped light having a uniform illuminance as projected into the environment exterior to the luminaire **100**. One or more of the components comprising the luminaire **100** may be connected by any means or method known in the art, including, not by limitation, use of adhesives or glues, welding, interference fit, and fasteners. Alternatively, one or more components of the luminaire **100** may be molded during manufacturing as an integral part of the luminaire **100**.

Continuing to refer to FIGS. **2**A and **2**B, the outer structure **130** of the lamp **110** also may comprise a shelf **210** and an optic **220**. The light source **225** may be disposed on the shelf **210** and oriented such that the source light emitted from the light source **225** passes through the optic **220**. The optic **220** may be configured to direct the source light emitted from a light source **225** to be incident upon the light guide **140**. The optic **220** may be formed of any transparent, translucent, or substantially translucent material including, but not limited to, glass, fluorite, and polymers, such as polycarbonate. Types of glass include, without limitation, fused quartz, soda-lime glass, lead glass, flint glass, fluoride glass, aluminosilicates, phosphate glass, borate glass, and chalcogenide glass.

Referring now to FIGS. **3**A, **3**B, and **3**C, and additionally to FIGS. **1**A, **1**B, and **1**C, the light guide **140** of the present embodiment of the luminaire **100** may include an inner surface **142**, an outer surface **144**, a mounting aperture **146**, and a bi-pin connector **148**. The components comprising the light guide **140** may be connected by any means known in the art, including, not by limitation, use of adhesives or glues, welding, and fasteners. Alternatively, one or more components of the light guide **140** may be molded during manufacturing as an integral part of the light guide **140**.

As described above, a portion of the outer structure **130** of the lamp **110** may be positioned adjacent to the light guide **140** in the assembled luminaire **100**. More specifically, the light source **225** of the lamp **110** may be configured to emit light incident upon the inner surface **142** of the light guide **140**. Materials present in the light guide **140** may change the source light into a shaped light using at least one of collimation, concentration, refraction, conversion, reflection, and/or diffusion. For example, and without limitation, the shaped light may illuminate a space proximate to the luminaire in a generally even distribution along the length and/or width of the light guide **140**.

As shown in FIGS. **1**C, **3**A and **3**B, the light guide **140** may have a bi-pin connector **148** configured to mechanically attach to a standard fluorescent socket **106**. For example, and without limitation, the bi-pin connector **148** may be configured to conform to a standard bi-pin socket **106** for a fluorescent lampholder that is well known in the art. However, the light guide **140** may be configured to mechanically attach via the bi-pin connector **148** to any fluorescent socket **106**, including, but not limited to, medium bi-pin sockets (T8/T12), mini bi-pin sockets (T5/T5HO), single pin sockets (T12/T8), and U-bend medium bi-pin sockets. Additionally, the bi-pin connector **148** may be configured to conform to various sizes and configurations of the aforementioned sockets, including, but not limited to, turn-type sockets, pedestal sockets, and fixed-end sockets. The bi-pin connector **148** may be made of a non-conductive material which may support mechanical attachment to the fluorescent socket **106**, but which may not allow electrical current to pass through the light guide **140**. For example, and without limitation, the length of the bi-pin connector **148** may be long enough to provide mechanical attachment to the fluorescent socket pin contacts, but not long enough to engage the electrical connections within the socket pin contacts.

Continuing to refer to FIGS. **1**C, **3**A and **3**B, the light guide **140** may have a substantially elongated-basket shape that defines an inner surface **142** and an outer surface **144**. The outer structure **130** of the lamp **110** may be positioned adjacent to the inner surface **142** of the light guide **140** when the lamp **110** is received by the mounting aperture **146** of the light guide **140**. In some embodiments, the one or more light sources **225** in the outer structure **130** of the lamp **110** may be arranged such that each points substantially upwards towards a target reflective area on the inner surface **142** of the light guide **140**. This configuration may advantageously enhance light dispersion as light is emitted from the lamp **110**, resulting in an inexpensive way to distribute a light pattern that covers the entire target space proximate to the lighting system **100**.

For example, and without limitation, as illustrated in FIGS. **1**C, **3**A and **3**B, the mounting aperture **146** may be positioned on a substantially frustoconical single end of the elongate-basket shaped light guide **140** that may be opposite a second end to which the bi-pin connector **148** may be connected. The mounting aperture **146** may be sized to fittedly receive lamp **110** such that the bi-pin connector **112** and the middle structure **120** may pass through the mounting aperture **146**, but the shelf **210** of the outer structure **130** of the lamp **110** may be too large to pass through the mounting aperture **146**.

The inner surface **142** may include one or more of any type of reflective materials which may be known in the art. For example, and without limitation, the inner surface **142** may be formed of a material that is inherently reflective of light, and therefore a surface upon which emitted light may be incident inherently would be reflective. As another example, the inner surface **142** may be formed of a material that may be polished to become reflective. As yet another example, the inner surface **142** may be formed of a material that is permissive of a material being coated, attached, or otherwise disposed thereupon, the disposed material being reflective. As yet another example, as illustrated in FIG. **3**C, the light guide **140** may comprise layers of transmissive **310** and reflective **320** materials. Properties such as, and without limitation, the thickness and the orientation of the transmissive **310** and reflective **320** materials may be manipulated to alter the intensity and direction of the shaped light depending on the distance from a given reflective area on the inner surface **142** of the light guide **140** to the one or more light sources **225** in the outer structure **130** of a lamp **110**. As yet another example, it is contemplated that a coating may be placed on the inner surface **142** of the light guide **140** to convert a wavelength of the source light so that the wavelength is defined has having a converted wavelength range. For additional disclosure regarding coatings used to convert a wavelength of a source light, see U.S. patent application Ser. No. 13/234/371 titled Color Conversion Occlusion and Associated Methods, and U.S. patent application Ser. No. 13/357/283 titled Dual Characteristic Color Conversion Enclosure and Associated Methods, the entire contents of each of which are incorporated herein by reference. These methods of forming the light guide **140** are exemplary only and do not serve to limit the scope of the invention. All methods known in the art of forming the reflective inner surface **142** are contemplated and included within the scope of the invention.

Additionally, in some embodiments, the luminaire may be configured to conform to a U-bend florescent bulb configuration, such that the luminaire may be a legacy retrofit for such a troffer fixture. In such embodiments, the light guide may be configured to redirect light such that light is emitted substantially equally throughout the light guide, including those sections of the light guide that are generally distal of the human relative to the light source. Aside from this characteristic, U-bend luminaire embodiments of the invention may be substantially similar or identical to the linear embodiment presented herein, including all necessary and optional features described therewith, with the exception of each feature that must be reconfigured to conform to a U-bend type troffer fixture.

Referring now to FIGS. **1**A, **1**B, **1**C, **4**A and **4**B, the heat dissipating frame **170** of the present embodiment of the lighting system **100** may include a contact surface **172**, a mounting surface **174**, and a through-hole **176**. For example, and without limitation, the contact surface **172** on the heat dissipating frame **170** may be positioned in thermal communication with the outer surface **144** of the light guide **140**. The components comprising the heat dissipating frame **170** may be connected by any means known in the art, including, not by limitation, use of adhesives or glues, welding, and fasteners. Alternatively, one or more components of the heat dissipating frame **170** may be molded during manufacturing as an integral part of the heat dissipating frame **170**. A rim of the through-hole **176** may be in thermal communication with the heat sink section **124** of the middle structure **120** of the lamp **110**.

Continuing to refer to FIG. **1**C, the heat dissipating frame **170** of the luminaire **100** according to an embodiment of the present invention may include one or more heat sink rods **173** that may abut each other to define the contact surface **172** of the heat dissipating frame **170**. In various implementations, the heat dissipating frame **170** may be made of aluminum or other heat-conducting material by molding, casting, or stamping. A through-hole **176** may be disposed at a substantially frustoconical attaching end of the heat dissipating frame **170**. The through-hole **176** may comprise a rim, defined as a perimeter of the through-hole **176**, that may be sized to mechanically and thermally couple the heat dissipating frame **170** to the heat sink section **124** of the middle structure **120** of the luminaire **100** (illustrated in FIG. **2**A). For example, and without limitation, in the luminaire **100** presented in an assembled position as illustrated in FIG. **1**B, the through-hole **176** of the heat dissipating frame **170** may be aligned with the mounting aperture **146** of the light guide **140** with the contact surface **172** of the heat dissipating frame **170** substantially adjacent to the outer surface **144** of the light guide **140**. The lamp **110** may be received simultaneously by both the mounting aperture **146** and the through-hole **176** before mechanically and electrically engaging the fluorescent socket **106** with its bi-pin base **112**. In such a configuration, the weight of the heat dissipating frame **170** may be supported by the outer surface **144** of a light guide **140** that is mechanically attached to opposing fluorescent sockets **106** by the bi-pin connector **148** and by the anchored lamp **110**, respectively. Additionally, the mounting surface **174** of the heat dissipating frame **170** may be mechanically attached to a lighting assembly **102** using brackets **179** as illustrated in FIGS. **1**B and **1**C.

In various implementations of the present invention, the luminaire **100** may be configured as a retrofit to engage mechanically and operationally with a conventional fluorescent light fixture. The luminaire **100** shown in FIGS. **1**A, **1**B, and **1**C is an advantageously simple and inexpensive retrofit option in terms of manufacturing, installation and maintenance. For example, the design of the present invention avoids the material waste inherent to prosthetic tube retrofit designs. Furthermore, the on-board power conditioning for LED-based lighting provides for operation of the present invention using existing fluorescent light assembly circuitry and without requiring removal of fluorescent ballasts. The use of LEDs in connection with the lighting system **100** according to an embodiment of the present invention also advantageously provides decreased operating costs with respect to energy consumption. Also, LED-based technology supports tailoring of color temperature in ways not possible with standard fluorescent bulbs (e.g., color temperatures of 3000 Kelvin and below). Additionally, LED-based technology enables the adjustment of color temperature post-installation without requiring replacement of the bulb.

A method aspect of the present invention is directed to assembling a luminaire as a retrofit for a fluorescent tube lamp. The method may comprise the steps of removing the fluorescent tube lamp from a fluorescent light fixture, positioning the heat dissipating frame in thermal contact with the light guide, aligning the through-hole in the heat dissipating frame with a mounting aperture in the light guide, inserting the bi-pin base and the middle structure of the lamp through the mounting aperture in light guide and, in turn, through the through-hole of the heat dissipating frame such that outer structure of the lamp is fixedly attached to the light guide adjacent the mounting aperture. The method also may include attaching the bi-pin connector of the light guide to the first fluorescent socket, and mechanically and electrically attaching the pin lock of the bi-pin base to the second fluorescent socket. The method also may include positioning the light guide in relation to the light source such that the emitted source light is incident upon the light guide, and is changed by the light guide into the shaped light that illuminates the space proximate to the luminaire.

Referring now to FIG. **5**, and continuing to refer to FIGS. **1**A, **1**B, and **1**C, a method aspect **500** for retrofitting a fluorescent tube lamp with a luminaire **100** adapted to be carried by a lighting fixture **106** will now be discussed. From the start **505**, the retrofit method **500** may include the step of removing a legacy fluorescent lamp from the light fixture **106** (Block **510**). At Block **520** the heat dissipating frame **170** may be positioned to be carried by the light guide **140**. For example, and without limitation, the contact surface **172** of the heat dissipating frame **170** also may be positioned in thermal communication with the outer surface **144** of the light guide **140**. At Block **530**, the through-hole **176** of the heat dissipating frame **170** may be aligned with the mounting aperture **146** of the light guide **140** such that the lamp **110** may be received simultaneously by both the mounting aperture **146** and the through-hole **176**. At Block **540**, the bi-pin base **112** and the middle structure **120** of the lamp **100** may be inserted through the mounting aperture **146** and the through-hole **176** such that the shelf **210** of the outer structure **130** of the lamp **110** abuts the light guide **140**. The bi-pin connector **148** of the light guide **140** may be mechanically attached to a first fluorescent socket **106** at Block **550**. The bi-pin base **112** of the lamp **110** may be mechanically and electrically attached to a second fluorescent socket **106** at Block **560**. In such a configuration, the weight of the heat dissipating frame **170** may be supported by the outer surface **144** of the light guide **140** that is mechanically attached to opposing fluorescent sockets **106** by the bi-pin connector **148** and by the anchored lamp **110**, respectively. At Block **570**, the light source **225** of the lamp **110** may be configured to emit light incident upon the inner surface **142** of the light guide **140** such that the light guide **140** may change the source light into the shaped light that may illuminate the space proximate to the luminaire in a generally even distribution along the length and/or width of the light guide **140**. The process ends at Block **575**.

Some of the illustrative aspects of the present invention may be advantageous in solving the problems herein described and other problems not discussed which are discoverable by a skilled artisan. While the above description contains much specificity, these should not be construed as limitations on the scope of any embodiment, but as exemplifications of the presented embodiments thereof. Many other ramifications and variations are possible within the teachings of the various embodiments. While the invention has been described with reference to exemplary embodiments, it will be understood by those skilled in the art that various changes may be made and equivalents may be substituted for elements thereof without departing from the scope of the invention. In addition, many modifications may be made to adapt a particular situation or material to the teachings of the invention without departing from the essential scope thereof. Therefore, it is intended that the invention not be limited to the particular embodiment disclosed as the best or only mode contemplated for carrying out this invention, but that the invention will include all embodiments falling within the scope of the appended claims. Also, in the drawings and the description, there have been disclosed exemplary embodiments of the invention and, although specific terms may have been employed, they are unless otherwise stated used in a generic and descriptive sense only and not for purposes of limitation, the scope of the invention therefore not being so limited. Moreover, the use of the terms first, second, etc. do not denote any order or importance, but rather the terms first, second, etc. are used to distinguish one element from another. Furthermore, the use of the terms a, an, etc. do not denote a limitation of quantity, but rather denote the presence of at least one of the referenced item.

Many modifications and other embodiments of the invention will come to the mind of one skilled in the art having the benefit of the teachings presented in the foregoing descriptions and the associated drawings. The scope of the invention should be determined by the appended claims and their legal equivalents, and not by the examples given Therefore, it is understood that the invention is not to be limited to the specific embodiments disclosed.

That which is claimed is:

1. A luminaire comprising:

a lamp comprising:
- an outer structure,
- a light source configured to emit a source light and carried by the outer structure,
- a middle structure connected to the outer structure, and
- a bi-pin base connected to the middle structure;

a light guide having an inner surface and an outer surface; and

a heat dissipating frame having a contact surface in thermal communication with the outer surface of the light guide and comprising a plurality of heat sink rods positioned to abut each other to define the contact surface of the heat dissipating frame;

wherein the light source is configured to emit the source light so as to be incident upon the inner surface of the light guide; and

wherein the light guide is configured to change the source light into a shaped light that illuminates a space proximate to the luminaire.

2. The luminaire according to claim **1** wherein the bi-pin base comprises a pin lock configured to anchor the lamp to a standard fluorescent socket.

3. The luminaire according to claim **1** wherein the outer structure of the lamp further comprises a shelf and an optic; and wherein the light source is disposed on the shelf and oriented such that the source light emitted from the light source passes through the optic.

4. The luminaire according to claim **1** wherein the light guide is further configured to change the source light into the shaped light using at least one of collimation, concentration, refraction, conversion, reflection, and diffusion.

5. The luminaire according to claim **1** wherein the inner surface of the light guide comprises an optically transmissive material and a reflective material that are configured, in combination, to change the source light into the shaped light.

6. The luminaire according to claim **1** wherein the light guide comprises a conversion material configured to convert a wavelength of the source light so that the wavelength of the shaped light is defined as having a converted wavelength range.

7. The luminaire according to claim **1** wherein the light guide comprises a bi-pin connector configured to mechanically attach to a standard fluorescent socket.

8. The luminaire according to claim **7** wherein the light guide comprises a mounting aperture positioned opposite the bi-pin connector; and wherein the mounting aperture is sized to fittedly receive at least one of the bi-pin base and the middle structure of the lamp such that a portion of the outer structure of the lamp is positioned adjacent to the light guide.

9. The luminaire according to claim **8** wherein the light guide comprises a substantially elongated-basket shape between the bi-pin connector and the mounting aperture.

10. The luminaire according to claim **1** wherein the heat dissipating frame comprises a through-hole positioned on a substantially frustoconical attaching end of the heat dissipating frame.

11. A luminaire comprising:

a lamp comprising:
- an outer structure,
- a light source configured to emit a source light and carried by the outer structure,
- a middle structure connected to the outer structure, and
- a bi-pin base connected to the middle structure;

a light guide having an inner surface and an outer surface and comprising:
- a bi-pin connector configured to mechanically attach to a standard fluorescent socket, and
- a mounting aperture positioned opposite the bi-pin connector,
- wherein the mounting aperture is sized to fittedly receive at least one of the bi-pin base and the middle structure of the lamp such that a portion of the outer structure of the lamp is positioned adjacent to the light guide; and

a heat dissipating frame having a contact surface in thermal communication with the outer surface of the light guide;

wherein the light source is configured to emit the source light so as to be incident upon the inner surface of the light guide; and

wherein the light guide is configured to change the source light into a shaped light that illuminates a space proximate to the luminaire.

12. The luminaire according to claim **11** wherein the bi-pin base comprises a pin lock configured to anchor the lamp to a standard fluorescent socket.

13. The luminaire according to claim **11** wherein the outer structure of the lamp further comprises a shelf and an optic; and wherein the light source is disposed on the shelf and oriented such that the source light emitted from the light source passes through the optic.

14. The luminaire according to claim **11** wherein the light guide is further configured to change the source light into the shaped light using at least one of collimation, concentration, refraction, conversion, reflection, and diffusion.

15. The luminaire according to claim **11** wherein the inner surface of the light guide comprises an optically transmissive material and a reflective material that are configured, in combination, to change the source light into the shaped light.

16. The luminaire according to claim **11** wherein the light guide comprises a conversion material configured to convert a wavelength of the source light so that the wavelength of the shaped light is defined as having a converted wavelength range.

17. The luminaire according to claim **11** wherein the light guide comprises a bi-pin connector configured to mechanically attach to a standard fluorescent socket.

18. The luminaire according to claim **11** wherein the heat dissipating frame comprises a through-hole positioned on a substantially frustoconical attaching end of the heat dissipating frame.

19. The luminaire according to claim **11** wherein the light guide comprises a substantially elongated-basket shape between the bi-pin connector and the mounting aperture.

20. The luminaire according to claim **11** wherein:

the middle structure comprises a heat sink section in thermal communication with the light source; and

the heat dissipating frame comprises a through-hole disposed on an attaching end of the heat dissipating frame and positioned such that a rim of the through-hole is in thermal communication with the heat sink section of the middle structure of the luminaire.

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